

What is claimed is:

1 1. A apparatus for measuring a gate oxide thickness,
2 which is disposed in a scribe line region, comprising:
3 a first active area disposed on a substrate, a width of
4 the first active area is a predetermined width of
5 at least $2F$;
6 first to fifth wordlines disposed on the substrate in
7 a first direction, with a first predetermined space
8 between each two wordlines, and the first ends of
9 the first to fifth wordlines are electrically
10 connected;
11 first and second bar-shaped trench capacitors disposed
12 under the second and the fourth wordlines
13 respectively, with a second predetermined space
14 between the first and second bar-shaped trench
15 capacitors, the first and second bar-shaped trench
16 capacitors are longer than the first active area;
17 wherein the first space is smaller than the
18 second space, and F is a minimum line width
19 of the wordlines; and
20 first and second gate structures respectively disposed
21 between the first bar-shaped trench capacitor and
22 the second wordline and between the second
23 bar-shaped trench capacitor and the fourth
24 wordline, each gate structure comprising a gate
25 conducting layer and a gate oxide layer, wherein
26 the gate conducting layers are electrically
27 connected to the wordlines respectively.

1 2. The apparatus for measuring a gate oxide thickness
2 of claim 1, wherein the first to fifth wordlines are electrically
3 connected to a first conducting layer.

1 3. The apparatus for measuring a gate oxide thickness
2 of claim 1, wherein the first predetermined space is the minimum
3 line width F of each of the wordlines.

1 4. The apparatus for measuring a gate oxide thickness
2 of claim 1, wherein the width of the second predetermined space
3 is $3F$.

1 5. The apparatus for measuring a gate oxide thickness
2 of claim 1, further comprising a second active area having
3 a predetermined width of at least $2F$, the second active area
4 disposed on the substrate in a second direction, and the first
5 active area is connected to the second active area by a second
6 conducting layer.

1 6. The apparatus for measuring a gate oxide thickness
2 of claim 1, wherein the width of the second predetermined space
3 is $3F$.

1 7. The apparatus for measuring a gate oxide thickness
2 of claim 1, further comprising a doped layer disposed on the
3 substrate under a second end of each wordline.

1 8. The apparatus for measuring a gate oxide thickness
2 of claim 1, wherein the first direction and the second direction
3 are approximately perpendicular.

1 9. An apparatus for measuring a gate oxide thickness,
2 which is disposed in a scribe line region, comprising:

a first active area disposed on a substrate, a width of the first active area is a predetermined width of at least $2F$;

first to fifth wordlines disposed on the substrate in a first direction, with a minimum linewidth F between each two wordlines, and first ends of the first to fifth wordlines are electrically connected;

first and second bar-shaped trench capacitors disposed under the second and fourth wordlines respectively, the first and second bar-shaped trench capacitors are longer than the first active area, and with a predetermined space with $3F$ between the first and second bar-shaped trench capacitors;

first and second gate structures respectively disposed between the first bar-shaped trench capacitor and the second wordline and between the second bar-shaped trench capacitor and the fourth wordline, each gate structure comprising a gate conducting layer and a gate oxide layer, wherein the gate conducting layers are electrically connected to the wordlines respectively, and

a doped layer disposed on the substrate under second ends of the first to fifth wordlines.

10. The apparatus for measuring a gate oxide thickness of claim 9, further comprising a second active area having a predetermined width of at least $2F$, the second active area disposed on the substrate in a second direction, and the first active area is connected to the second active area by a second conducting layer.

1 11. The apparatus for measuring a gate oxide thickness
2 of claim 9, wherein the first to fifth wordlines are electrically
3 connected to a first conducting layer.

1 12. The apparatus for measuring a gate oxide thickness
2 of claim 9, wherein the first direction and the second direction
3 are approximately perpendicular.

1 13. A gate oxide thickness measurement, comprising:
2 providing a wafer with a scribe line and a memory cell
3 area;

4 forming a measuring apparatus on the scribe line, and
5 forming a plurality of memory cells with vertical
6 transistors in the memory cell area, wherein each
7 vertical transistor has a gate oxide layer,

8 wherein the measuring apparatus comprises:
9 a first active area disposed on a substrate,

10 a width of the first active area is a
11 predetermined width of at least $2F$;

12 first to fifth wordlines disposed on the
13 substrate in a first direction, with a
14 minimum line width F between each two
15 wordlines, and first ends of the first
16 to fifth wordlines are electrically
17 connected;

18 first and second bar-shaped trench capacitors
19 disposed under the second and fourth
20 wordlines respectively, the first and
21 second bar-shaped trench capacitors are
22 longer than the first active area, and

with a predetermined space of 3F between
the first and second bar-shaped trench
capacitors;

first and second gate structures respectively
disposed between the first bar-shaped
trench capacitor and the second wordline
and between the second bar-shaped trench
capacitor and the fourth wordline, each
gate structure comprising a gate
conducting layer and a gate oxide layer,
wherein the gate conducting layers are
electrically connected to the wordlines
respectively;

measuring an equivalent capacitance between the first
conducting and the first active area;

estimating a thickness of the gate oxide layer of the
measuring apparatus according to the equivalent
capacitance; and

estimating a thickness of the gate oxide layer of each
vertical transistor according to the thickness of
the gate oxide layer of the measuring apparatus.

14. The gate oxide thickness measurement of claim 9,
wherein the thickness d of the gate oxide layer of the measuring
apparatus is obtained by a formula: $C = \frac{\epsilon}{d} \times A$, wherein C is the
equivalent capacitance, ϵ is a dielectric constant of the gate
oxide layer, and A is a contact area between the gate oxide
layer of the measuring apparatus and the first active area.